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Dental Caries and Fluorosis in Children Residing in a Non Water Fluoridated Community Receiving Fluoride Supplementation Compared with Dental Caries and Fluorosis in Children Residing in a Water Fluoridated Community

by

Manal A. Awad (C)

A thesis
submitted to the Faculty of Graduate Studies and Research
in partial fulfilment of the requirements for the degree of

Master of Science

Faculty of Dentistry

Edmonton, Alberta
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M Awad

(Student's signature)

604 D Michener

Park Edmonton

Alberta Canada

(Student's permanent address)

Date: Oct 6th 1989

The University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled

Dental Caries and Fluorosis in Children Residing in a Non Water Fluoridated Community Receiving Fluoride Supplementation Compared with Dental Caries and Fluorosis in Children Residing in a Water Fluoridated Community

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(Supervisor)

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Date: .....

ABSTRACT

Fluoride supplementation is an alternative way of providing fluoride to children when water fluoridation is not available.

The caries experience and dental fluorosis of two groups of children were compared. The first group consisted of 160 children living, since birth, in a less optimal fluoridated area. These children had been offered sodium fluoride in the form of drops for daily use. The second group of 129 children were living in an optimal fluoridated water area (1 ppm fluoride) since birth. Two age range were selected, children 7-9 years old for the younger group and 11-14 years old for the older group, with an average of 7.3 and 12.4 years of age respectively.

Dental examination as well as questionnaires mailed to the parents were used to collect the required information on age of starting fluoridated toothpaste usage, breastfeeding period and residency.

The results showed that no statistically significant difference could be observed between the groups with regard to their means of decayed, missing, filled teeth (dmft) and means of decayed, missing, filled surfaces (dmfs), on their deciduous

dentition. However, the permanent dentition of the children living in the water fluoridated area had significantly lower means of decayed, missing, filled teeth (DMFT) and decayed, missing, filled surfaces (DMFS), when compared with the permanent dentition of the supplement group.

Percentage of children with dental fluorosis was higher in the children of the supplementation group than for the water fluoridated group.

No statistically significant difference was observed in dental caries between the regular and irregular compliers of the fluoride supplement.

Toothpaste usage and breastfeeding did not appear to influence dental caries experienced by the children in this study.

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CHAPTER 1

INTRODUCTION

The use of fluoride in the control of dental caries is by far the most efficient method of preventing dental caries. Fluoride has both systemic and topical action of importance in dental health. Systemically, fluoride acts on teeth before their eruption by becoming incorporated into the crystal structure of enamel, making it resistant to decay. Topically, it acts by diffusing into enamel, where it is incorporated into the tooth's superficial layers making it more resistant to decay. This topical effect is a significant mechanism in the prevention of tooth decay. Exposure of the tooth surface to small, regular doses of fluoride may be more critical in preventing caries than fluoride which is ingested during tooth formation. Nevertheless the greatest caries reduction occurs when fluoride is available on a regular basis both systemically and for topical application on erupted teeth.

The prevalence of dental caries is decreased in children who live where the communal water supply is fluoridated and who use topical fluoride agents. In communities where water fluoridation is not available dietary fluoride supplements such as fluoride vitamin supplements, fluoride tablets and fluoride drops are recommended for children for safe effective prevention of dental caries.

It should be emphasized that the fluoride administration is primarily systemic and it is intended to increase fluoride intake to approximately the amount that would be obtained from fluids in optimal fluoridated communities.

The effect of fluoride tablets as a method of reduction of dental caries on a daily basis has proven to be effective in most of the studies completed on this method. The role of fluoride drops as a daily supplement, particularly related to compliance, is not clearly documented.

Studies have shown that children who have been receiving fluoride supplement during the entire pre-eruptive period of the permanent teeth had a distinct advantage with respect to caries experience.

Alternative methods to fluoridated water are supplied usually only once a day, therefore they may result in transiently higher fluoride levels in the plasma than are achieved with optimal water fluoridation. This peaking may affect the normal formation of enamel and could lead perhaps to mild dental fluorosis, although dental fluorosis of aesthetic significance occurs only in children who receive excessive fluoride (more than 1 mg F) on regular basis.

1.1 Aim Of The Study

The aim of this study was to measure the long term effect of dietary fluoride supplements given by parents in the form of sodium fluoride drops for children

living in a non water fluoridated area (study group), compared to children living in a 1ppm optimally water fluoridated community (control group). The criteria used for assessment included:

1. Dental caries.
2. Fluorosis.
3. Compliance.

1.1.1 Dental Caries

Comparing past dental caries experience between the study and control groups, to evaluate the level of dental caries obtained with fluoride supplementation of the children using it, compared to children who have been living in a fluoridated water community. Clinical examination on dental caries using the World Health Organization (WHO) criteria was undertaken in both groups.

1.1.2 Fluorosis

Measuring fluorosis in the study and control groups to see if there is an increase risk for the children on fluoride supplementation compared to the children who are living in the fluoridated water community. Fluorosis clinical examination was completed using the Tooth Surface Index of Fluorosis (TSIF) for the children in

the study and control groups.

1.1.3 Compliance

A questionnaire designed to gain information on the compliance was used in respect of the regularity or irregularity of fluoride supplementation by children in the study group, along with other information needed on the method of taking the supplement, accuracy of giving the exact number of drops, and number of topical fluoride that the child might have had.

CHAPTER 2

LITERATURE REVIEW

2.1 Fluoride and Dental Caries

Fluoride in drinking water is the most effective, safest and cheapest way of preventing dental caries. Its effect is both pre-eruptive and post-eruptive and it also has the added advantage that no conscious cooperation on the part of the individual is required. The first community water fluoridation scheme began in Grand Rapids, U.S.A. in 1945 and was quickly followed by other large scale studies in North America. According to the WHO [1], clinical studies have shown that the observed reduction in the prevalence of dental caries due to water fluoridation ranged from 40 to 50 percent in the primary dentition, and between 50 to 60 percent in permanent teeth [2]. Other studies have shown that during adulthood the use of fluoridated water also leads to fewer dental caries. Long term studies revealed that the caries protection effect may be diminished or wholly eliminated if water fluoridation is interrupted, thus great importance is attached to the continuous water fluoridation [3]. However when water fluoridation is not available to all populations, other alternatives, including fluoride supplementation, could be used.

Fluoride will have a pre-eruptive systemic effect on developing teeth as well as a topical effect if ingested in one of these forms, fluoridated water, sodium fluoride tablets or drops and fluoridated milk or salt. Topically, fluoride is used in mouthrinses and toothpastes at home or applied to erupted teeth in dental clinics in the form of topical solutions, gels or varnishes. The use of mouthrinses, as a means of reduction of dental caries, has been shown to be effective in many studies [4].

Leske et al. [4] suggest that there was a persistent effect of weekly rinsing up to 2.5 years, after treatments were discontinued. In this study, an average DMFS (decayed, missing, filled surfaces) difference of 24.4 percent was observed, comparing students who had rinsed for 2-4 years to students of the same age who were examined at the baseline.

Eckhaus et al. [5], in a study on Livermore school children in California, where the children rinsed each week with a 0.2 percent sodium fluoride mouthwash, showed that after 3 years there was a 33 percent reduction in their DMFS, compared to the baseline examination. The authors suggest that fluoride mouthrinsing should be used continuously through the adolescent years so that the potential benefits might be achieved.

Joyston-Bechal [6], reported that in Hungary and Switzerland fluoridated salt had been used for several years as an alternative to water fluoridation with some success. In other studies 2.5 ppm F has been added to milk and this method has

been used in some parts of Austria, West Germany, Japan and Switzerland [6]. In 1972 a self - administered fluoride program was initiated in Nelson county, USA [7] a fluoride deficient area; grade 1 - 8 children ingested daily 1 mg fluoride tablets, rinsed weekly with a 0.2 percent sodium fluoride solution and also were provided with a fluoride dentifrice for use at home. After eight years, the results indicated that participating children had fewer carious tooth surfaces than their counterparts at the baseline examination. Overall, the dental examination of children ages 6 to 14, who had continuously participated in the program for one to eight years depending on their grade, had an overall mean caries prevalance of 3.22 DMFS ; 49 percent lower than the corresponding mean score of 6.31 DMFS for children of the same ages at the base line examination. In 1974, 12 year old children who participated for 2 years, had a mean DMFS just above 8. In 1976, 12 year old children who had participated for 4 years in the fluoride program had a mean DMFS of 6.4. In 1978 and 1980, 12 year old children who had been 6 years in the fluoride program had a mean DMFS of 4.8, and 5.3 respectively. These authors concluded from their data that the caries declines in their groups were significantly related to the earlier involvement and subsequently the longer exposure to the fluoride program. They also concluded that the decline in dental caries was attributed to the fluoride program and not from a natural decline in caries prevalance.

Aasenden and Peebles [8] showed that children 7- 12 years old, ingesting fluoride supplements from shortly after birth (0.5/mg day) to the age of 3 years and 1mg/day there after, had marked reduction of dental caries. A follow-up study 5 years later [9] on the children age range 12-17 years, showed that the mean caries score of fluoride supplement group was 80% lower than that of the control group. In 1978, a report by Binder et al. [10] on data from 18 studies which investigated the cariostatic effects of fluoride tablets on the deciduous dentition, showed that the benefits were greater in those studies in which the initial age of the children was 2 years or younger; the reduction ranged from 50 to 80 percent. Also, data from studies which investigated the cariostatic effect of fluoride tablets on permanent teeth of children 13 year old who consumed 0.25 mg fluoride for a minimum of 5 years between 6 months and 6 years of age, showed no benefits regarding reduction of dental caries, while others reported a reduction of 20 to 40 percent.

Driscoll et al. [11], found after 6 years of chewing, rinsing with and swallowing acidulated phosphate fluoride tablets containing 1 mg of fluoride, either once or twice a day, that the fluoride tablets reduced the incidence of dental caries when compared to a control group using placebo tablets.

Thylstrup et al. [12] concluded from their study on children who had been given fluoride tablets from shortly after birth that there was a significant inhibition of dental caries in the primary dentition, but only for those who received more than 1,600 tablets and used them continuously. No difference in dental caries was

observed in the permanent dentition.

Driscoll [13] after a review of studies on the use of prenatal fluoride administration for prevention of dental caries, concluded that from a theoretical stand point, primary teeth could benefit from prenatal exposure to dietary fluoride supplements but permanent teeth are unlikely to benefit from the procedure. He also suggested that the use of fluoride supplements during pregnancy should not be recommended.

A study by Widenhiem [14] on Swedish children consuming fluoride tablets and the attitude of the parents towards the fluoride supplementation, showed that the frequency of non users had increased mostly among families with a higher parental education. A reason given why they did not give their children the fluoride tablets implied that they might be dangerous to swallow. Some parents mentioned that they were not advised to give there children the fluoride tablets, however, according to this study, the use of tooth paste and mouthrinses were well accepted.

Allmark et al. [15] showed that after six years of using fluoride tablets children who started at the age of six years had a 59 percent decrease in their decayed, filled teeth (DFT) scores and 61 percent decrease in their decayed, filled surfaces (DFS) scores when compared to children who had never been on the fluoride tablets supplementation.

Friis-Haschè et al. [16] found from their study that there was no significant difference in dental caries between children who had been using fluoride tablets for 1-4 years and those who never used fluoride tablets.

Smyth [17], compared children who were not using fluoride tablets to those who were occasional users and others who were daily users of the tablets. According to the data presented, occasional users of the fluoride tablets differed only from the nonusers in the number of decayed teeth. However, the daily users, exhibited highly significant differences in the mean number of decayed teeth, mean number of DMF, and the proportion of caries free children when compared with the nonusers. Kuthy et al. [18] reported on the fluoride prescription practice of Ohio physicians; they found that pediatricians were more likely to prescribe fluoride supplements than their family physician and that only a small percentage of those physicians who prescribe fluoride inquire about the content of the child's drinking water.

The Canadian Paediatric Society Nutrition Committee [19] recommended that in communities where the concentration of fluoride in the water supply is less than 0.7ppm, infants and children should receive a supplement, and that the supplements should continue until the age of 12 year old. They also recommended caution for the routine use of fluoride-vitamin preparations as the potential danger of a fluoride overdose increases with their use.

Heiftz et al. [20] conducted a survey in several areas of Illinois with optimal and above optimal water fluoride concentration, to determine the prevalence of dental caries and dental fluorosis. The results of caries prevalence showed that DMFS scores in all three above optimal fluoride areas were lower than in the optimal area, also the highest caries protection was at the three times above optimal area.

In an Australian study [21], on children in the age range of 3 and 6 years who were either taking fluoride tablets daily or occasionally, the results showed that 89% of children aged 3-4 years, 81% of age 4-5 years and 77% of those age 5-6 who had taken daily fluoride tablets throughout their life had a zero dmft (decayed, missing, filled teeth) score. The percentage with a zero score decreased as the length of time tablets were taken became shorter. Children in all age groups who took tablets daily for periods of less than two years failed to derive any protection against dental caries; and in the oldest group (5-6 years) no protection was obtained unless tablets had been taken for at least three years.

Beltran and Burt [22] recently reviewed studies discussing the post and pre-eruptive effects of fluoride in caries decline. In early studies, reports of the initial fluoridation field trials included little discussion about the mechanism by which fluoride acted, but it was implied that the fluoride was effective principally by being incorporated into developing enamel to form a stronger or more acid resistant fluorapatite crystal. It was long assumed that maximum benefits from fluoridation were seen in the first cohorts to consume fluoridated water from birth [23] and that fluoride had a pre-eruptive effect on developing teeth [24]. Driscoll et al. [25] in their study of the long term benefits from supervised ingestion of fluoride supplements supports the suggestion that pre-eruptive fluoride effects are observable. Regarding the post-eruptive enamel effects some early studies mentioned the dental benefits to teeth that had already erupted at the time the

fluoridation began. A British report [26] and Danish studies [12,27,28] support the concept of posteruptive enamel effects. If fluoride is present at the time of acid challenge, it will diffuse with the acid and inhibit dissolution at the crystal surface and, if it is present during remineralization, it enhances crystal growth and hence makes the overall reminerlization process more rapid and effective. However studies had suggested that postreuptive effects of fluoride supplementation is not enough to be equal to living in a fluoridated water community and also there is still a gap in caries experience between fluoridated and nonfluoridated water communities [29]. Beltran and Burt [22] give a reasonable explanation stating that fluoride is increasingly available from several sources, and that fluoride incorporated in surface enamel, stored in plaque and to some extent found in saliva, is therefore always available when needed, and that remineralization is continually becoming more efficient.

A recent report by Burt and Beltran [30] responded to critics from Australia and New Zealand who questioned the effectiveness of water fluoridation. Both authors from Australia [31] and New Zealand [32,33] concluded that the caries decline has occurred independent of fluoride and that fluoridation should not be continued as public policy. The argument of Diesendorf [31] from Australia is that the decline in dental caries is not attributed to water fluoridation and only partly to other uses of fluoride. He suggests that dietary changes and possible changes in the immune system are responsible for the changes in dental caries. Colquhoun [32,33] from

New Zealand based his argument on the results from some previous studies which found that the oral health of children living in a non-fluoridated water area was better than that of children living in a fluoridated water area. Burt and Beltan questioned the reliability of the studies Diesendorf and Colqhoum based their opinions on. They state that fluoride in several delivery forms continues to play a major role in the caries decline among children However, they suggest that further research should be directed at answering questions about optimum amounts of fluoride and the efficiency and practicality of various delivery methods, and conclude that the current practice is safe and efficient.

2.2 Fluoride and Fluorosis of Tooth Enamel

Dental fluorosis is a hypoplasia or hypomineralization of tooth enamel or dentin produced by the chronic ingestion of excessive amounts of fluoride during the period when teeth are developing. The major determinant of the prevalence and severity of dental fluorosis has been shown to be the concentration of fluoride in the water consumed by infants and children during the first five years of life. Mineralization of permanent teeth other than the third molars, occurs from about the time of birth until approximately five years of age. After that time, teeth other than third molars, are completely mineralized and cannot produce fluorosis because of excessive fluoride ingestion, nor is it possible after that time to diminish already-

produced fluorosis by lowering consumption of dietary fluoride [46]. One of the first reports of what was probably dental fluorosis was made by Kuhns in 1888 [34], who described teeth of persons in areas of Mexico that were opaque discoloured, and disfigured. Mckay and Black [35] reported a condition they called Colarado Brown Stains, among persons living in a specific location; they later showed this was due to fluoride in the water supply. Dean [36] conducted a series of surveys that elucidated, the relation between the occurrence of dental fluorosis and the concentration of fluoride in drinking water. He developed a classification system in 1934 for assessing the presence and severity of dental fluorosis of teeth. In 1942 he modified the system [37]. Some investigators developed new classification systems or indexes that record all defects in enamel, based on descriptive criteria. The classification systems of Al-Alousi et al. [38], Jackson et al. [39] Murray and Shaw [40], are all based on the principal that an examiner should record only what is seen and not try to presume an etiology for the condition. Thylstrup and Fejerskov [41] proposed a new classification system of dental fluorosis based on pathology of tooth enamel; the classification included 10 scores designed to characterize the degree of dental fluorosis affecting buccal,lingual and occlusal surfaces. However, some investigators disagree with those systems; Horowitz [42] describes and prefers indexes that distinguish fluoride from nonfluoride opacities such as Dean [37], Moller [43], Zimmerman [44], Nevitt et al. [45] and TSIF [46].

Goward [47], in a study of the assessment of mottling in incisor teeth in children 13 to 14 years old in Liverpool England, who had been born and lived in Liverpool where the fluoride content of the water supply had an average of 0.12 ppm F, found a mouth prevalence of mottling of 42.5 percent, and a tooth prevalence of mottling of 9.6 percent. After comparing the data to those of other investigators, the author concluded that a considerable proportion of mottling observed in fluoride and non fluoride water communities was caused by factors other than ingested fluoride.

Aasenden and Peebles [9], in their study on children who had been given fluoride tablets shortly after birth and had been followed for five years after the initiation of the first examination, found that the mean score of fluorosis in the fluoride group was lower at the second examination than at the first one. According to these findings, the authors suggest that it appears that the enamel fluorosis of the mild and very mild degree may fade to some extent with time, possibly because of continued mineralization or due to abrasion.

Thylstrup and Fejerskov [41], using their classification system of dental fluorosis, conducted a study on children born in areas with 3.5, 6.0, and 21.0 ppm F in the water supply. After examining permanent and primary dentitions for dental fluorosis, and using their system, the results revealed that the severity of fluorosis was lower in primary teeth when compared to permanent teeth. A significant increase in severity was noted in both dentitions with increasing concentration of

fluoride in the drinking water. The distribution of dental fluorosis within the dentition followed the same pattern irrespective of fluoride content of the drinking water. They also compared results using their system with the results using Deans index [37], they found that Deans index was unable to distinguish between dental fluorosis and other tooth defects in the 6.0 and 21.0 ppm F area. They state it is possible with their system to diagnose fluorosis in posterior teeth which were significantly more affected in the latter area.

Holm and Anderson [48], studied enamel in 12 year old children with a known early exposure to fluoride tablets and/or fluoride containing toothpaste. Results showed that children who had consumed fluoride tablets for a period of at least 12 months comencing at age six months ran a 5.4 times greater risk of developing enamel fluorosis than children with no such consumption. No such risk could be shown in children who at 6 or 12 months of age started to use fluoridated tooth paste.

Moller [49] showed that although both primary and permanent teeth may be affected by fluorosis, under uniform conditions of fluoride availability, fluorosis tends to be greater in permanent teeth than in primary teeth. The authors suggest that the reasons might be that the period of enamel formation for primary teeth is shorter than for permanent teeth and that the enamel of primary teeth is thinner and has greater opacity than permanent teeth making detection of fluorosis more difficult.

Allmark et al. [50] showed that there was no difference between the prevalence of mottling of permanent teeth that had erupted during their study period comparing the test and the control group.

de Liefde and Herbison [51] studied the developmental defects of enamel in 9 year old children in New Zealand receiving fluoride supplementation, their results showed that diffuse opacities occur in children with a low fluoride intake, but the prevalence increases in groups of children given fluoride supplementation. The authors explain the results stating that diffuse opacities may in some cases be fluorotic defects but that factors other than fluoride may cause clinically indistinguishable diffuse opacities.

Other workers looking at all types of enamel defect have attempted to see the involvement of fluorides in enamel defects aetiology. Several papers at a recent symposium on enamel defects held in New Zealand in 1988 looked critically at detection of differences considered to be due to fluoride with those considered to be from other causes. No firm concensus was achieved; the papers will appear in Advances in Caries Research but at the time of writing have not been published [52].

Larsen et al. [53], compared children who had participated in a fluoride tablet program to those who had never received fluoride supplement. The data showed that there was an increased risk of fluorosis for children who received the fluoride supplements especially in the age groups of 2.5 to 3.4 years. For the 3.5 to 5.4 year

age group the time of starting the supplementation affected the findings. The data also showed that fluoride can affect teeth late in their development when enamel is in a stage of late secretion or early maturation.

Granath et al. [54] compared the diagnosis of mild enamel fluorosis on permanent maxillary incisors using Dean's index [37] and the index of Thylstrup and Fejerskov [41]. They examined 13 year old children who had been using fluoride tablets for a minimum of 5 years between the age of six month and six years of age, and examined a control group children who had never been on fluoride tablets. According to Dean's scores there was no statistical significance between the two groups, however the Thylstrup and Fejerskov system did show a statistical significant difference between the two groups.

Fejerskov et al. [55], conducted a study on primary teeth of caries free children who had been exposed to systemic fluoride tablets from 3 month prenatally to 7 years of age. The children were also treated with fluoride gels every 4 weeks. After five years of age, the histological and chemical examination of these teeth showed that the fluoride tablets were capable of producing fluorotic lesions and that those lesions were limited to postnatal enamel. The authors concluded that the fluoride supplementation given immediately after birth could produce pronounced dental fluorosis in the primary dentition. They also stated that prenatal systemic fluoride may have added to the risk of dental fluorosis developing even in postnatal enamel.

In a study by Heifetz et al. [20] on Illinois children, they found that by comparing the TSIF scores in 1980 to 1985 surveys, for children age 8-10 years old in each fluoride category, the two sets of data showed that the prevalence and severity of dental fluorosis increased two times and three times the optimal level compared with the optimal level. Also the data showed that younger children had distinctly more fluorosis than the older children in both first molars and incisors at all fluoride levels [46]. They mentioned that these results might be explained by the suggestions of Asenden and Peebles [9] and that of Thylstrup and Fejerskov [41] that abrasion or continued mineralization may eliminate the mild forms of fluorosis with time. Another explanation suggested, is that younger groups of children may have consumed greater amounts of fluoride during tooth development as fluoride was more available to them than to the older children.

2.3 Compliance

In examining compliance of fluoride supplements, it is important to review the concepts of compliance in health studies. Compliance is defined by Taylor and Sackett [56] as the extent to which a person's behaviour (in terms of taking medications, following diet or executing lifestyle changes) coincides with medical or health advice. Measuring compliance is important as there is always a gap between the recommended regimen and that adhered to by the patient, so it is important

to measure it for either research or clinical purposes.

In research studies, the focus may be on the extent of non-compliance and its effect on the outcome of the study. Taylor and Sackett state that "It is important to distinguish between non-compliance and medication errors, in case of medication errors, the patients intellectual limitations or other circumstances may have confused him so that he does not or cannot follow the instructions, on the other hand, non-compliance implies an intent not to follow instructions" [56].

2.4 Methods of measuring compliance

2.4.1 Direct Methods

Blood levels or urinary excretion of the medication are used as direct methods, the problem is the technical aspects of the test itself, including its sensitivity and specificity as a method of detection. The other problem is classifying a patient as a complier or non-complier.

2.4.2 Indirect Methods

The outcome of the treatment or preventive regimen appears to be a reasonable measure of compliance, if there is sufficient faith that the recommended regimen,

when adhered to is truly effective. The outcome is frequently affected by many factors such as socio-economic status and cultural factors.

Interview of the patient could be also used, the problem is that often patients lie about their taking the medication. In some studies the investigators compared interview responses with pill count and with urine test and they found a difference [57].

Another indirect method could be the comparison between the the amount of medication remaining in the patients bottle compared with the quantity that should have remained. However the bottle count was considered misleading by some investigators [58].

It is interesting to note that according to some studies reviewed by Taylor and Sackett [56], the features of the disease are unimportant as determinants of compliance. Duration of the treatment has an unequivocal effect on compliance, as many studies [59,60] showed that adherence to treatment decrease with time. A common claim made by clinicians and echoed by drug manufactures in their advertising is that side effects cause non-compliance.

2.5 Health Belief Model (HBM)

This theory argues that whether or not an individual will undertake a recommended health action is dependant upon that individuals perceptions of:

(1) Level of personal susceptibility to the particular illness or condition.

(2) Degree of severity of the consequences which might result from contracting the condition.

(3) The health actions potential benefits or efficacy in preventing or reducing susceptibility and/or severity .

(4) Physical, psychological, financial, and other barriers or cost related to initiating or continuing the advocated behaviour.

Using this model in a study on obesity in children [61], the model was useful in explaining and predicting a mothers adherence to a diet regimen prescribed for her child.

Taylor and Sackett [56], mentioned that most studies neglect compliance as an important variable in statistical analysis. Also some doctors dismiss patients who reject their recommendations. The authors suggests that non-compliance patients can serve as a control group and results can be compared to those patients who received the treatment.

In dental research, some studies [12,17] investigated the effect of compliance on the dental caries and fluorosis experienced by the children using fluoride supplement.

CHAPTER 3

MATERIALS AND METHODS

3.1 Selection of Samples

3.1.1 Study Group

The sample of children in this study is based on a group of children enrolled in a supplementation program in the Health Unit district of Sturgeon in central Alberta, Canada. 2600 children (up to the age of 14), were on the supplementation, out of that number, 980 children were eligible for the dental fluorosis study on the basis of age criteria. Two main age groups, 6-8 year old and 11-13 years old children, were identified. Qualification for inclusion in either of the two age categories was arbitrarily determined according to the following formulas:

a) for 6-8 year old, birthdates between June, 1978 and May 31, 1981

b) for 11-13 year old, birthdates between June 1, 1973 and May 31, 1976

300 children were randomly selected as defined by the major independent variable of age.

With the aid of random numbers, the sample was tabulated into two separate lists of children numerically arranged and distinguished by age. Attention was given to

include a proportionate number of children in each single year age group in the overall age category up to the quota of 150 children in each cell. Attention was also given to include roughly equal numbers of boys and girls in each step of the selection process. Last, over sampling was done by 10% in the young age group and 20% in the older age category so as to ensure sufficient numbers in each group. This over selection of roughly 10-20%, compensated for the approximate 8.6% sample drop-out rate experienced during data collection in the field. These children were randomly distributed over the entire health unit area. In several cases these were as a few as one child in any school and as many as 50 in any location.

For various reasons such as relocation, failure to locate records, or an unusually remote location, or special circumstances (residence on a Hutterite colony), a number of replacement subjects were required. Attention was given to selecting substitutes from the same age categories, and if possible from the same school or nearest designated survey site. Where possible, gender replacement was required, but that was not always possible. To the extent that the substitutes were selected according to the above requirements, the randomized nature of the overall sample was intentionally compromised by allowing matched replacements rather than randomized selection.

The final number of children actually examined was 266 children, distributed over each of the two major age categories. The initial data collection was completed in the summer of 1987.

A questionnaire was mailed to the parents of the children to provide information that were relevant to the study. The parents of the children were approached in 1987/1988 academic year to obtain additional information on compliance. It was possible to reach 160 children from the original number (60%). The parents were contacted directly by phone, all the phone interviews were done by the author. This was approved by the Medical Officer of Health of the Sturgeon Health Unit who authorized involvement of the health unit workers in the investigation.

Out of the 160 children involved in the compliance study, 90 children were in the 7-9 years old group, 49 boys with mean age of 7.6 and s.d 0.92, 41 girls with mean age 7.4, s.d 0.92. 70 children in the 11-14 years old group, 40 boys with mean age 12.5, s.d 1.00, 30 girls with mean age 12.05 s.d 1.08. The amount of fluoride in the children's drinking water ranged from 0.0 to 0.95 mg/L, due to independent well sources.

3.1.2 Control group

A control group of children was selected from the 1ppm fluoride drinking water region of Metropolitan Edmonton, Alberta, Canada using the same age range criteria as the study group.

Following discussion with the Director, Dental Health Services Division of Edmonton Board of Health, three schools were selected as being typically

representative of the social classes of the region and representing similar socio-economic categories of the Sturgeon Health Unit district.

The Supervisor of Monitoring for the Edmonton Public Schools, Edmonton Board of Education approached the head teachers of three schools and all the children in the age selected were invited to participate in the study. Over 90% of the parents agreed to the dental examinations and to complete the questionnaire related to the study.

This method of selection identified 60 children in the 7-9 years old age range, 31 boys with mean age 7.10, s.d 0.39, 29 girls with mean age 7.07, s.d 0.25. 69 children in the 11-14 years old group, 30 boys with mean age 12.00 s.d 0.20, 39 girls with mean age 12.05, s.d 0.22.

The dental caries and fluorosis examinations were performed by the same examiners in both, the study group as well as the control group, Drs. J.A. Hargreaves, G.W. Thompson, with the author attending examining sessions.

3.2 Dental caries

The dental caries examination for both the study and control groups were completed using the WHO method and criteria as shown in appendix A.

3.3 Dental fluorosis

The dental fluorosis examination for both the study and control groups, was completed using the TSIF [46], as shown in appendix C.

3.4 Fluoride Supplement

The Administrative Dental Officer at the Sturgeon Health Unit, based the computerized, fluoride supplementation on the equivalent of 1.2 ppm fluoride (appendix C), in the drinking water, as optimum for Northern Alberta, relative to numidity and ambient temperature [62].

3.5 Potential Confounder Variables

In addition to the dental caries and fluorosis records, more information was recorded, for possible factors which could play a roll in the dental caries and fluorosis experienced by the children in the study including residency, breastfeeding and toothpaste usage.

3.5.1 Residency

It was of great importance to know if the children lived in the same area all their lives, or if they moved to another area with different fluoride concentration in their drinking water.

3.5.2 Breastfeeding

Breastfeeding was considered as a confounder variable as the mothers milk has little fluoride, whereas using powdered milk and formulae could contain fluoride.

3.5.3 Toothpaste usage

With the assumption that most of the available toothpaste in the market has fluoride added to it, the age of starting toothpaste usage is of importance, in respect of both dental caries and possible fluorosis.

3.6 Questionnaire

The first questionnaire was mailed to the parents of the children in the study population, to gain initial information (appendix D).

In 1988 the parents were approached by phone interviews to gain information specifically on compliance (appendix E). This questionnaire gathered additional information to ascertain if the children were exposed to other sources of systemic fluoride and topical fluorides. It was considered important to know if the parents restricted the number of drops prescribed for each child in the study according to prescriptions.

The question on the frequency of compliance was asked in both questionnaires to reconfirm the regularity or irregularity of giving the fluoride supplement to the children.

3.7 Compliance

Due to cell numbers, a child was considered a good complier, if he/she was taking the fluoride supplement three or more times a week, and a poor complier was a child taking the supplement less than three times a week.

The questionnaire answered by the parents of the children in the control group was the same as the first questionnaire mailed to the parents of the children in the study group deleting the part on the compliance.

3.8 Dental Fluorosis

Specific permanent teeth were identified for comparison of fluorosis:

a) The left maxillary central incisor

b) The right mandibular central incisor

c) The left maxillary first molar

d) The right mandibular first molar

In the younger group (7-9 years old), as the only permanent teeth consistingly erupted were incisors and first molars, these specific teeth were therefore chosen for further study in both age groups.

3.9 Statistical analysis

Spss (Statistical Package for Social Sciences), statistical package was used to analyze the data [63].

3.9.1 Data file

A data file was created to contain the dental and fluorosis records of the children in both the study and control groups (appendix F) Fluorosis was recorded as absent or present regardless of its degree. The degree of fluorosis was calculated

individually.

Questions number 4, 6 and 7 in the second questionnaire (appendix E) were not added to the data file since all the parents answers were (NO), also question number 5 was not added since parents claimed that they did not stop giving the supplement to their children. The answers to the question on the topical fluoride exposure for the study group were calculated individually. Coding included age, sex, toothpaste usage, breastfeeding, residency, fluorosis and compliance, as shown in appendix D. Although residency was added to the data file, no further analysis was done as all the children in both the study and control groups had lived continuously in the same area where they were located.

3.9.2 Student t-test

Student t test for independent groups was used to compare the overall difference between means of dmft, DMFT, dfs and DFS in both the study and control groups.

3.9.3 ANOVA

One way analysis of the variance (ANOVA) was used to compare differences of means of dental caries in both the study and control groups on each of the following independent variables:

Toothpaste usage

Breastfeeding

Sex

Compliance (only in the study group).

Two-way analysis of variance was used to evaluate the effect of the two groups (study and control) on each of the following independant variables:

Toothpaste usage:

- Children using toothpaste since one year old and one to two years old, were recorded as group 1.
- Children using toothpaste from two to three years old and after three years old, were recorded as group 2.

Breastfeeding:

- Children not breastfed, breastfed for less than one month or from one to three months, were recorded as group 1.
- Children breastfed for four to six months and more than six months, were recorded as group 2.

Sex:

-Male.

-Female.

CHAPTER 4

RESULTS

4.1 Dental Caries

The average scores of dmft and DMFT for the study group and the control group are shown in table 1.

4.2 Study Group

4.2.1 Primary Teeth

The dmft for the children in the 7-9 years old group was 2.78 for boys and 2.46 in girls; their dmfs was 5.49 in boys and 4.22 in girls.

4.2.2 Permanent Teeth

The DMFT for the 7-9 years old group was 0.94 in boys and 0.93 in girls and the DMFS was 1.04 and 1.10 respectively.

In the 11-14 years old group, the results show that the boys had a DMFT of 2.50 and the girls DMFT was 2.73, while the DMFS for boys was 3.30 and 3.67 in girls.

4.3 Control Group

4.3.1 Primary Teeth

The average scores of dmft for the 7-9 years old group as shown in table 1 were 1.81 in boys and 2.41 in girls, and their dmfs was 3.32 and 3.79 respectively.

4.3.2 Permanent Teeth

The mean DMFT for the same age group was 0.10 in boys and 0.28 in girls, with a DMFS of 0.16 and 0.31.

In the 11-14 years old group the mean DMFT in boys was 1.63 and 1.74 in girls, their DMFS was 2.23 and 2.38 respectively.

There was a statistical significant difference in dental caries at the 0.05 level ($p<0.05$) between the study and control groups in permanent dentition in both age groups with the control group having a lower dental caries prevalence compared to the study group.

Table 2 shows a comparison between the study group and the control group on their dfs, and their DFS.

Table 1

DMFT, dmft, DMFS and dmfs for Children in the Study and Control Groups.

age	sex	number of children	dmft	s.d	dmfs	s.d	DMFT	s.d	DMFS	s.d
study group										
7-9	boys	49	2.78	3.16	5.49	7.63	0.94*	1.41	1.04*	1.60
n=90	girls	41	2.46	2.43	4.22	4.77	0.93*	1.23	1.10*	1.64
11-14	boys	40					2.50*	2.56	3.30*	3.93
n=70	girls	30					2.73*	2.36	3.67*	4.05
control group										
7-9	boys	31	1.81	2.73	3.32	5.17	0.10*	0.40	0.16*	0.73
n=60	girls	29	2.41	2.78	3.79	4.57	0.28*	0.84	0.31*	1.00
11-14	boys	30					1.63*	1.83	2.23*	2.79
n=69	girls	39					1.74*	2.20	2.38*	3.87

* Statistically significant comparing study with control groups ($p<0.05$)

Table 2

DFS and dfs for Children in the Study and Control Groups.

		dfs					DFS				
	sex	o	b	m	l	d	O	B	M	L	D
study group											
7-9	boys	2.22	0.55	0.90	0.49	1.29	0.67	0.24	0.00	0.06	0.00
n=90	girls	1.98	0.32	0.41	0.44	0.70	0.63	0.29	0.00	0.09	0.00
11-14	boys						2.28	0.50	0.05	0.40	0.05
n=70	girls						2.27	0.40	0.53	0.30	0.13
control group											
7-9	boys	1.55	0.13	0.52	0.09	0.61	0.06	0.03	0.00	0.00	0.00
n=60	girls	2.38	0.28	0.48	0.31	0.76	0.28	0.07	0.00	0.00	0.00
11-14	boys						1.63	0.36	0.07	0.17	0.00
n=69	girls						1.49	0.36	0.28	0.18	0.05

(O,o) Occlusal Surfaces
(B,b) Buccal Surfaces
(M,m) Mesial Surfaces
(L,l) Lingual Surfaces
(D,d) Distal Surfaces

4.4 Tooth Surface Distribution of Dental Caries

4.4.1 Primary Teeth

In the 7-9 years old children, for the study group 41% of the caries was in the occlusal surface in boys while in girls it was 52%, in the control group 53% of the caries in boys was in the occlusal surface and 56% in girls. The buccal and lingual surfaces had the same percentage of caries in both boys and girls in the study group (20%), while in the control group 8% of the caries was in boys and 14% in girls.

The percentage of dental caries in the mesial and distal surfaces in boys in both the study and control group is almost equal (40%, 39% respectively) but was less in the girls (28%, 30% respectively).

4.4.2 Permanent Teeth

The results show that the occlusal surface in the 7-9 years old presented the highest percentage of dental caries, 69% in boys in the study group and 60% in girls, while in the control group 67% of the caries was represented by this surface in all boys and 80% in girls. However the mesial and distal surfaces were caries free in boys in the study group, and in girls only the mesial surfaces were caries free. In the

control group in both boys and girls the mesial, lingual and distal surfaces were caries free.

For the 11-14 years old children, the boys in the study group had 70% of the caries in the occlusal surface, while in the control group they had 73% of the caries in the occlusal surface. 27% of the caries was represented by the buccal and lingual surface in the boys in the study group and 24% in the control group, however the boys in the control group had no caries in their distal surfaces and only 3% of the DFS was represented by the mesial surfaces. In the study group 3% of the caries was in the mesial and distal surfaces.The girls in the study group and the control group had almost the same percentage of caries in the occlusal surface (62%, 63%) respectively, the buccal and lingual surfaces in the study group had 20% of the mean DFS while in the control group these surfaces had 23% of the caries. Mesial and distal surface represented 18%of the caries in the girls in the study group and 14% in the control group.

Table 3, shows the means of dental caries in both the study and control groups, excluding the caries free children. The percentage of children who were caries free in the study group in the 7-9 years old was 35%. In the control group, 52% of the children were caries free in their primary dentition, while 53% of the child in the study group did not have caries in their permanent dentition. In the control group 90% of the children in the same age group were caries free.

Table 3

DMFT and dmft, Excluding Caries Free Children, for the Study and Control Groups

		total number of children	children with caries	dmft	s.d	DMFT	s.d
study group	boys	49	33	4.12	3.01	--	
7-9 years	girls	41	26	3.88	1.98	--	
control group	boys	31	13	4.31	2.62	--	
7-9 years	girls	29	16	4.38	2.31	--	
study group	boys	49	22	--		2.09	1.41
7-9 years	girls	41	20	--		1.90	1.11
control group	boys	31	2	--		1.50	0.70
7-9 years	girls	29	4	--		2.00	1.41
study group	boys	40	30	--		3.33	2.44
11-14 years	girls	30	24	--		3.42	2.15
control group	boys	30	16	--		3.06	1.34
11-14 years	girls	39	21	--		3.24	2.02

In the 11-14 years old the results show that 25% of the children in the study group where caries free and 46% in the control group did not have dental caries. However there were no statistically significant differences between the means of dmft or DMFT between the study group and the control group at the .05 level of significance ($p>0.6$ and $p>0.5$ respectively).

4.5 Toothpaste Usage

Table 4 shows the mean dmft and DMFT for the children in the study group as well as in the control group, according to the age of starting toothpaste usage. From the table it could be shown that for the 7-9 years old children the highest percentage of the children in the study group used the toothpaste from 1-2 years of age (38%), the lowest percentage used the toothpaste after the age of 3 years old (11%), but there were no statistically significant differences between the means of dmft and DMFT ($p>0.3$ and $p>0.08$ respectively).In the control group the highest percentage of children in the same age group were using the toothpaste from 2-3 years of age (32%), and the lowest percentage used the toothpaste after the age of 3 years (14%). However their means of dmft was almost equal (1.79, 1.78), the difference between their DMFT was not statistically significant ($p>0.7$).

Table 4

DMFT and dmft, According to the Age of Starting Toothpaste Usage, for the Study and Control Groups

	age of starting toothpaste usage	number of children	dmft	s.d	DMFT	s.d
Study group						
7-9 years	1 year	24 (27%)	1.58	2.30	0.54	0.66
n = 90	1-2 years	34 (38%)	3.17	3.00	0.94	1.31
	2-3 years	22 (24%)	3.32	3.21	1.09	1.54
	After 3 years	10 (11%)	1.80	1.81	1.40	1.89
11-14 years	1 year	14 (20%)			3.14	2.68
n = 70	1-2 years	22 (31%)			2.63	2.44
	2-3 years	18 (26%)			2.00	2.38
	After 3 years	16 (23%)			2.75	2.49
Control group						
7-9 years	1 year	16 (27%)	2.68	3.34	0.18	0.54
n = 60	1-2 years	16 (27%)	2.06	2.26	0.25	0.10
	2-3 years	19 (32%)	1.79	2.89	0.05	0.23
	After 3 years	9 (14%)	1.78	2.27	0.33	0.71
11-14 years	1 year	12 (17%)			1.42	1.44
n = 69	1-2 years	27 (39%)			1.70	2.23
	2-3 years	17 (25%)			2.05	2.01
	After 3 years	13 (19%)			1.46	2.22

In the 11-14 years old group the highest percentage of the children used the toothpaste from 1-2 years of age in both the study group (31%) and the control group (39%), also the lowest percentage of the children had used the toothpaste since 1 year old, 20% in the study group and 17% in the control group.There was no statistically significant difference in the means of the DMFT between the children in either of the four grouping in the study group or in the control group ($p>0.6$).

Table 5 shows the means of dmft and DMFT for the children in the study and control groups when comparing children who used toothpaste since one year and 1-2 years of age to those who used the toothpaste since 2-3 years or after three years of age. There were no statistically significant differences in the means of dmft ($p>0.8$) or the DMFT ($p>0.6$) within the two groupings in the study group or in the control group.

4.6 Breastfeeding

Table 6, shows that most of the children in the 7-9 years old group, in the study group as well as in the control group, were not breastfed or were breastfed for less than one month; 33% in the study group and 43% in the control group.There were no statistically significant differences in the dmft ($p>0.6$) or the DMFT ($p>0.5$) within the groups in either the children in the study or control groups. The highest

Table 5

Age of Starting Toothpaste Usage of Children in the Study and Control Groups related to dmft and DMFT

	age of starting toothpaste usage	number of children	dmft	s.d	DMFT	s.d
Study group						
7-9 years	1 year, 1-2 years	58	2.52	2.80	0.79	1.10
n = 90	2-3 years, After 3 years	32	2.84	2.90	1.19	1.60
11-14 years	1 year, 1-2 years	36			2.83	2.50
n = 70	2-3 years, After 3 years	34			2.35	2.40
Control group						
7-9 years	1 year, 1-2 years	32	2.38	2.80	0.21	0.79
n = 60	2-3 years, After 3 years	28	1.78	2.70	0.24	0.45
11-14 years	1 year, 1-2 years	39			1.61	2.01
n = 69	2-3 years, After 3 years	30			1.80	2.10

Table 6

DMFT and dmft, According to the Period of Breastfeeding, for the Study and Control Groups.

	Period of breastfeeding	number of children	dmft	s.d	DMFT	s.d
Study group						
7-9 years	No, or<1month	30 (33%)	2.79	2.75	1.10	1.42
n = 90	1-3 month	20 (22%)	2.35	2.64	1.00	1.34
	4-6 month	14 (16%)	3.50	3.05	0.50	1.09
	>6 month	26 (29%)	3.42	3.02	0.92	1.32
11-14 years	No, or<1month	43 (61%)			2.93	2.57
n = 70	1-3 month	16 (24%)			2.00	1.93
	4-6 month	6 (8%)			1.83	2.78
	>6 month	5 (7%)			2.60	2.88
Control group						
7-9 years	No, or<1month	26 (43%)	1.92	2.84	0.12	0.43
n = 60	1-3 month	13 (22%)	2.46	2.99	0.30	1.10
	4-6 month	13 (22%)	1.84	2.82	0.15	0.38
	>6 month	8 (13%)	2.50	2.27	0.25	0.70
11-14 years	No, or<1month	39 (56%)			1.60	1.04
n = 69	1-3 month	14 (20%)			2.21	2.36
	4-6 month	7 (10%)			1.71	2.21
	>6 month	9 (14%)			1.33	1.32

percentage of children in the 11-14 years group were the children who were not breast fed or breastfed for less than one month in both the study group (61%) and in the control group (56%). Also no statistical differences were found comparing the means of their DMFT ($p>0.5$).

Table 7 shows the means of dmft and DMFT for the children in the study and control group when comparing children who were not breastfed, breastfed for less than one month or for one to three months to children breastfed for four to six months or for more than six months. No statistically significant difference could be observed in the means of the dmft ($p>0.3$) or DMFT ($p>0.4$) between the children in either of the two groupings in the study group or in the control group.

4.7 Fluorosis

The number of children in both the study group and in the control group with fluorosis were compared together with the degree of the fluorosis (table 8). In the study group, 51% of the children had fluorosis in the 7-9 years old group, while in the control group only 25% of the children in the same age group had fluorosis.In the 11-14 years old children, 50% of the children in the study group had fluorosis and in the control group 20% of the children had fluorosis.However in both the study group as well as in the control group most of the fluorosis, as shown in the table, is fluorosis 1 (white flakes).

Table 7

Period of Breastfeeding of Children in the Study and Control Groups related to dmft and DMFT

	period of breastfeeding	number of children	dmft	s.d	DMFT	s.d
Study group						
7-9 yrs	No, <1 month, 1-3 months	50	2.50	2.60	1.06	1.30
n = 90	4-6 months, >6 months	40	3.20	3.04	0.77	1.20
11-14 yrs	No, <1 month, 1-3 months	59			2.68	2.40
n = 70	4-6 months, >6 months	11			2.18	2.70
Control group						
7-9 yrs	No, <1 month, 1-3 months	39	2.10	2.80	0.18	0.70
n = 60	4-6 months, >6 months	21	2.10	2.50	0.19	0.50
11-14 yrs	No, <1 month, 1-3 months	53			1.75	2.10
n = 69	4-6 months, >6 months	16			1.50	1.70

Table 8

Number of Children with Fluorosis and the Degree of Fluorosis, for the Study and Control Groups.

	Total number of children	Children with fluorosis	Degree of fluorosis	Percentage
Study group				
7-9 years	90	46 (51%)	fluorosis 1	93%
			fluorosis 2	4%
			fluorosis 3	0%
			fluorosis 4	3%
			fluorosis 5-7	0%
11-14 years	70	35 (50%)	fluorosis 1	91%
			fluorosis 2	7%
			fluorosis 3	1%
			fluorosis 4	1%
			fluorosis 5-7	0%
Control group				
7-9 years	60	15 (25%)	fluorosis 1	91%
			fluorosis 2	7%
			fluorosis 3	1%
			fluorosis 4	1%
			fluorosis 5-7	0%
11-14 years	69	14 (20%)	fluorosis 1	89%
			fluorosis 2	11%
			fluorosis 3	0%
			fluorosis 4	0%
			fluorosis 5-7	0%

In table 9 and table 10, the percentage of fluorosis is shown on specific permanent teeth (left maxillary first molar, right mandibular central incisor, left maxillary central incisor and the right mandibular first molar), for both the study group and the control group.

In the 7-9 years old children, 80% of the children in the study group with fluorosis, had no fluorosis in their permanent lower right mandibular central incisors, and in the control group 74% of the children of the same age showed no fluorosis on the same tooth.

It can be seen from the tables that a high percentage of the children in both the control and study groups had fluorosis 1 on the left maxillary first molar, permanent left maxillary central incisor and the right mandibular first molar.

In the 11-14 years old children, 83% of the children with fluorosis in the study group had no fluorosis in the lower right mandibular central incisor, in the control group 93% of the children did not have fluorosis on the same tooth.

4.7.1 Toothpaste Usage

Considering the relationship between the duration of toothpaste usage and fluorosis, in the study group, 55% of the children in the 7-9 years had fluorosis when using the toothpaste since the age of one year or from one to two years old. It was found that 44% of the children using toothpaste from two to three years old or after

Table 9

Percentage of Children in the 7-9 years old Study and Control groups with Degrees of Fluorosis for Four Selected Permanent Teeth.

	7-9 years old	
	Study group	Control group
left maxillary first molar		
fluorosis 0	35%	34%
fluorosis 1	57%	60%
fluorosis 2	6%	6%
fluorosis 3	0%	0%
fluorosis 4	2%	0%
fluorosis 5-7	0%	0%
right mandibular central incisor		
fluorosis 0	80%	74%
fluorosis 1	18%	26%
fluorosis 2	0%	0%
fluorosis 3	0%	0%
fluorosis 4	2%	0%
fluorosis 5-7	0%	0%
left maxillary central incisor		
fluorosis 0	42%	20%
fluorosis 1	54%	74%
fluorosis 2	2%	6%
fluorosis 3	0%	0%
fluorosis 4	2%	0%
fluorosis 5-7	0%	0%
right mandibular first molar		
fluorosis 0	44%	47%
fluorosis 1	50%	47%
fluorosis 2	4%	0%
fluorosis 3	0%	6%
fluorosis 4	2%	0%
fluorosis 5-7	0%	0%

Table 10

Percentage of Children in the 11-14 years old Study and Control groups with Degrees of Fluorosis for Four Selected Permanent Teeth.

	11-14 years old	
	Study group	Control group
left maxillary first molar		
fluorosis 0	52%	59%
fluorosis 1	40%	36%
fluorosis 2	8%	5%
fluorosis 3	0%	0%
fluorosis 4	0%	0%
fluorosis 5-7	0%	0%
right mandibular central incisor		
fluorosis 0	83%	93%
fluorosis 1	17%	7%
fluorosis 2	0%	0%
fluorosis 3	0%	0%
fluorosis 4	0%	0%
fluorosis 5-7	0%	0%
left maxillary central incisor		
fluorosis 0	35%	43%
fluorosis 1	40%	36%
fluorosis 2	17%	21%
fluorosis 3	3%	0%
fluorosis 4	5%	0%
fluorosis 5-7	0%	0%
right mandibular first molar		
fluorosis 0	69%	50%
fluorosis 1	31%	50%
fluorosis 2	0%	0%
fluorosis 3	0%	0%
fluorosis 4	0%	0%
fluorosis 5-7	0%	0%

three years old had fluorosis. For the 11 to 14 years old children, 61% had fluorosiswhen using the toothpaste from one year old or from one to two years old and 38% had fluorosis when using the toothpaste from two to three years old or after three years old.

4.7.2 Breastfeeding

Considering breastfeeding period and fluorosis, 60% of the children in the 7 to 9 years old group had fluorosis when not breastfed, breastfed for less than one month or for one to three months; while 40% of the children who were breastfed for four to six months or more than six months had fluorosis. In the 11 to 14 years old, 49% of the children who were not breastfed, breastfed for less than one month or for one to three months had fluorosis and 56% of the children who were breastfed for four to six months or more than six months had fluorosis.

4.8 Compliance

Children in the study group were divided into good compliers and poor compliers, table 11 shows the number of children in each group, and the means of their dmft and DMFT. The table shows that 50% of the children were good compliers in the 7-9 years old, while in the 11-14 years old group 47% of the children were good

compliers, however the difference in the means of dental caries between the good and poor compliers was not statistically significant at .05 level (dmft: $p>0.15$, DMFT: $p>0.4$).

When excluding the children who were caries free table 12 shows the means of dmft and DMFT for the children with dental caries according to their compliance. The results show that for the 7-9 years old children 44% of the children with dental caries in their deciduous teeth were good compliers and 56% were poor compliers, 50% of the children in the same age group with caries in their permanent dentition were good compliers. In the older group (11-14 years old) 50%of the children with caries in their permanent teeth were good compliers.

A comparison was made between the good compliers and the poor compliers to show the percentage of fluorosis in each of the two groups in both the younger group as well as in the older group. Table 13 shows that, in the 7-9 years old group, 49% of the good compliers developed fluorosis, and 53% of the poor compliers also developed fluorosis. In the 11-14 years old group, 63% of the good compliers developed fluorosis and 38% of the poor compliers had fluorosis.

Table 14 shows the method used by parents to give their children the fluoride supplement. The majority of the children (75%) were given the supplement in juice, 17% put the supplement in water, and 6% put it in milk. Only 2% used other methods or gave it directly to the children.

Table 11

DMFT and dmft for Children in the Study Group According to their Compliance,

	number of children	dmft	s.d	DMFT	s.d
7-9 years old (n=90)					
Good compliance	45	2.20	2.54	0.82	1.17
Poor compliance	45	3.06	3.07	1.04	1.46
11-14 years old (n=70)					
Good compliance	33	--	--	2.81	2.59
Poor compliance	37	--	--	2.40	2.56

Table 12

DMFT and dmft for Children, Excluding the Caries Free Children, in the Study Group According to their Compliance.

	Number of children		dmft	s.d	DMFT	s.d
7-9 years old (n=90)						
Good compliance	26	(44%)	3.81	2.25	--	--
Poor compliance	33	(56%)	4.18	2.86	--	--
7-9 years old (n=90)						
Good compliance	21	(50%)	--	--	1.76	1.36
Poor compliance	21	(50%)	--	--	2.24	1.37
11-14 years old (n=70)						
Good compliance	27	(50%)	--	--	3.44	2.45
Poor compliance	27	(50%)	--	--	3.30	2.16

Table 13

Number of Children in the Study Group with and without fluorosis and their Compliance.

		Good compliers	Poor compliers
7-9 years old (n=90)			
Fluorosis	absent	23 (51%)	21 (47%)
	present	22 (49%)	24 (53%)
11-14 years old (n=70)			
Fluorosis	absent	12 (37%)	23 (62%)
	present	21 (63%)	14 (38%)

Table 14

Method of Taking the Fluoride Supplement in the Study Group.

Method	Number of Children
Juice	119
Water	27
Milk	10
Others (or directly)	4

When looking at the number of topical fluorides that the children in the study groups, it was found that:

36% had topical fluoride application once a year

36% had topical fluoride application twice a year

25% had no topical fluoride application

3% had a history of at least one topical fluoride application

The parents found it difficult to be accurate about the age when their children started using the fluoride drops themselves without parental control. Some children, even the older ones, still had the drops administered daily by their parents. All the parents said that they never exceeded the recommended dosage on purpose.

CHAPTER 5

Discussion

The results showed that children living in an optimal water fluoridated area, have significantly lower past dental caries experience in their permanent dentition for both the younger and the older group (DMFT = 0.19 and 1.68 respectively), compared with the children using fluoride supplementation (DMFT = 0.94 and 2.61 respectively). Aasenden and Peebles [8] have shown that regular use of fluoride supplements by children living in areas with little fluoride in their drinking water, reduced caries prevalence when compared with children living in optimal fluoridated areas. However they mentioned that analysis of the drinking water of the children living in optimal fluoridated areas found that the water did not contain optimal concentration of fluoride at all times.

The present study showed that there was no statistically significant difference in dmft of the deciduous dentition for the 7-9 years old between the supplement group and the fluoridated water group. This suggests that both the supplement group and the water fluoridated group obtained similar benefit (or lack of benefit). These findings compared with those of Thylstrup et al. [12] who found that the regular use of fluoride tablets did cause reduction of dental caries on deciduous dentition, support his suggestion that a substantial part of the caries inhibition was due to the

topical effect of the fluoride. However they could not find any significant difference between the regular users and the occasional users on their permanent dentition. In a study by Fanning et al. [21] in Australia, she could not find any protection against dental caries when the tablets where given daily for less than two years after birth. de Liefde and Herbison [51] in New Zealand, found that children who stopped fluoride supplement by the age of 5-6 years did not benefit from the fluoride when compared to children who continued to use the supplement until the age of 9 years. Other studies did show that for children at schools commencing supplementation at age of 5-6 years, did still benefit their teeth [11,64] and again topical effect could explain the reduction in dental caries.

The present study on the means of dfs and DFS, showed that the occlusal surfaces were the most affected by dental caries. The fluoridated water group had more protection on their approximal surfaces when compared to the supplement group, which confirms the findings of Driscoll et al. [11] who suggested that the optimal fluoride levels would mainly tend to be more cariostatic on smooth surface and proximal surfaces than on pits and fissures. The pattern of distribution of dental caries was similar in both groups.

It is interesting to report, that although the percentage of children who were caries free in the fluoridated water group is much higher than that of the supplement group, the means of dmft, DMFT for children with dental caries were higher in the fluoridated water group than the supplement group. However the number of

children in the fluoridated water group was small (not statistically significant). There were no statistically significant differences between means of dental caries between the regular and irregular users of the fluoride supplementation in the younger children, although there was a trend towards fewer carious lesions in the regular users of the supplement on both permanent and deciduous dentitions. Comparing the means of DMFT and DMFS between the regular compliers and the water fluoridated group, a significant reduction in the latter group compared with the supplement group for this 7-9 years old children was shown. This trend was not seen in the older group of children; a possible explanation could be that as the children became older, they stopped taking the supplement regularly and their premolars and second molars did not obtain maximum benefit from the supplementation.

Prevalence of dental fluorosis, in this study is higher in the supplement group compared with the fluoridated water group, which agrees with the findings of Aasenden and Peebles [8], who found that the mean index of dental fluórosis in the fluoride supplement group to be twice as high as that of the fluoridated water group (0.88, 0.40 respectively). In the present study the percentage was even higher (51% in the supplement group, 21% in the fluoridated water group) and more teeth were affected in the supplement group than the fluoridated water group. The data on the distribution of the fluorosis among the children on their permanent dentition showed that maxillary central incisors were the most affected, followed by

the maxillary first molar, mandibular first molar and the mandibular central incisors except for the younger children in the supplement group where the maxillary first molar appears to be more affected than the maxillary central incisors. This could be explained by the findings of Thylstrup and Fejerskov [41], who suggested that a significant portion of the variance of dental fluorosis had been explained by the reduction of the enamel thickness. The finding that the mandibular first molar is less affected than the maxillary first molar is contrary to that reported by the same authors in their study.

The distribution of dental fluorosis was the same in both fluoridated water and fluoride supplement groups which was also reported by Thylstrup [65], who found that the distribution of fluorosis within the dentition followed the same pattern irrespectively of fluoride content of the water. This data shows that the younger children had distinctly more affected teeth with fluorosis than the older ones in both groups with the exception of the maxillary central incisor in the supplement group which, in the present study, appears to be more affected in the older group than in the younger group. This trend had been reported by Horowitz et al. [46], who found that the maxillary molars and central incisors, were more affected in the younger group than in the older ones. One explanation suggested by Aasenden and Peebles [9], was that abrasion, or continuous mineralization, may diminish the milder forms of fluorosis with time, Thylstrup and Fejerskov [41] who found that the occlusal surfaces of posterior teeth generally showed less fluorosis than the

buccal and lingual surfaces of the same teeth, also suggested that abrasion might lower the fluoride score. Another explanation was that the younger group of children may have consumed greater amounts of fluoride during tooth development as a result of availability of fluoride from multiple sources, than was available to older children at the time their corresponding teeth developed [66], for example more fluoridated toothpaste is available as well as fluoride from beverages made in fluoridated water regions [67].

The older children in the supplement group who were regular users of the supplement showed a trend towards more fluorosis than the irregular users of the supplementation, yet the prevalence of dental caries in this group was not statistically lower than the irregular users of the supplement. This finding was not expected and raises the question of the validity of the parents answer to the fluoride history of the children in this group. On the other hand 61 % of the children who had fluorosis in the older group were using toothpaste since they were one and one to two years old; also for the children in the older group second molars and premolars were included in the examination. The toothpaste usage could also contribute to the increase of fluorosis on the central incisors as in the younger group of children, post-eruptive enamel maturation of these teeth would not be fully completed at this young age. While there is no direct evidence of dental fluorosis from the ingestion of toothpaste alone [68], it may contribute to the problem, especially if children have been given fluoride supplement since infancy.

Some researchers [6,48] suggest that toothpaste should not be recommended until the child is 4 years old, when he/she can control swallowing, others suggest that there should be a delay in increasing the dose of fluoride supplement to 1 mg 4 years of age. Starting age of toothpaste usage did not appear to have any effect on the means of dmft or DMFT. Also, in this study, breastfeeding periods did not seem to have any effect on dental caries. In the younger group, children who were not breastfed, breastfed for less than one month or for one to three months, showed a trend towards more fluorosis more than children who were breastfed for four to six months or more than six months. In the older group, fluorosis did not seem to be higher in children who were not breastfed, breastfed for less than one month or for one to three months. This confirms the conclusion by Thylstrup [65] that additional fluoride ingested during early life preferentially enters the rapidly growing skeleton. Some researchers [69] regard the growing skeleton as a key factor in preventing dental fluorosis in sucking infants. All the fluorosis in the water fluoridated area was score 1 and 2. In the supplement group, some children did have more severe fluorosis of score 3 and 4.

The present study found that 12 children in the supplement group had over 0.7 ppm fluoride in their drinking water and they were still provided by supplement through the computer program developed for the region attempting to let all children have the equivalent of 1.0 to 1.2 ppm in drinking water sources [70].

The American Academy of Pediatrics [71] recommended a daily intake of 0.25 mg fluoride from two weeks up to the age of two years 0.5 mg fluoride from 2-3 years and 1 mg fluoride from 3 to 16 years in areas where the level of the fluoride in the water supply is less 0.3 ppm. The Council on Dental Therapeutics of the American Dental Association [72] recommended the same dosage schedule of the American Academy of Pediatrics, however they recommended the supplement until the age of 13 years old. In cases were the drinking water contained from 0.3 to 0.7 ppm fluoride, 0.25 mg fluoride is recommended from 2-3 years and 0.5 mg fluoride from 3-13 years of age. Above 0.7 ppm the American Dental Association did not recommend additional supplementation. The continuous use of supplement until the age of 16 has been recommended as there is evidence to suggest that cariostatic benefits diminish after fluoride supplementation is stopped [73]. A recent report by Beltran and Burt [22], suggests that this continuous exposure is not necessary, since remineralization is promoted by the frequent introduction of low concentrations of fluoride into the oral environment, the small amount of fluoride in the drinking water or even the use of other agents like tooth paste is sufficient to promote remineralization.

The importance of providing the supplement from birth or as soon as possible after birth is to attempt to make sure that fluoride is ingested prior to tooth eruption allowing fluoride to be partly incorporated into tooth enamel, during the secretory and pre-eruptive maturation period. The amount of fluoride deposited preeruptively

depends on its concentration in food, water, supplements ingested, the duration of the ingestion period, and the length of the pre-eruptive maturation stage. The principal benefits of pre-eruptive ingestion are considered to be improved crystallinity and reduced enamel solubility [22].

An important part in this study depended totally on the parents responses to the compliance of their children, which raises several questions, as it is difficult for the parents to recall retrospectively the frequency of administering the fluoride supplement to their children for such a long period of time. A follow up every year on the compliance by the suppliers of the supplement would have been more helpful in this study, however, this was not possible. Although most of the parents claimed at the time of the interview, that they did not stop giving the drops to their children, the irregularity of administring the supplement could vary from once a week to once a month or even less. The parents were not able to be specific, and it is possible that supplementation could have stopped for short periods of time. Because the supplement was mailed to families at different times it was difficult to know the duration of use of the fluoride drops.

The success of the daily home administration of a fluoride supplementation, depends on the cooperation of the parents and the children themselves, strong motivation and clear understanding of the necessity of regular daily intake are essential. These demands tend to severely restrict the effectiveness of this approach on a wide scale, but because of caries preventive potential, it should be encouraged,

where the necessary motivation can be achieved. Another approach which appears to be more suitable choice for public health programs, is administration of the supplements at schools and kindergarten. This procedure requires very little of the teachers time, it has been used successfully in many studies, and is practised on a program basis in several countries. The regimen requires the continued enthusiasm and cooperation of school officials, teachers and children. The essential requirement is that all school programs must be supervised and permanent motivation must be provided [10].

Based on the findings from this study and other studies reported, it is important to evaluate the extent of the benefit that might be obtained from fluoride supplementation. The risk of fluorosis, especially when this benefit in protection against dental caries does not measure up to that obtained from water fluoridation. In the present study about 50% of the children in the supplement group developed dental fluorosis, although most of it was of the mild form. Few children developed severe fluorosis in the supplement group; only one child in the water fluoridated group. But, more teeth were affected by fluorosis in the supplement group than the other group.

The validity of providing fluoride supplementation should be reevaluated!

CHAPTER 6

Conclusion

Water fluoridation is an effective and safe way of preventing dental caries, with no conscious cooperation on part of the individual required. However, in cases where water fluoridation is not available or possible, other alternatives should be considered.

The aim of the present study was to measure the long term effect of using fluoride supplementation in the form of drops for children living in areas with minimal fluoride or below optimal amount in their drinking water, comparing them to children who were resident in the city of Edmonton where the drinking water contained optimal amount of fluoride (1ppm).

The results showed that the children on the supplementation program did not have as good a protection against dental caries as the children living in the city of Edmonton.

Fluoride supplements could help in reducing dental caries, but because of the difficulty in compliance and the risk of fluorosis involved, other alternatives such as supplementation through schools, rather than in the home, individual topical application of fluoride through professional administration or the addition of fluoride to salt should be considered.

More research is needed to determine a better way of providing fluoride for protection against dental caries when fluoride at the optimal dosage in the drinking water is not available.

Fluoride supplementation under the control of the parent or the child, based on this study, shows that a child can be at risk of developing fluorosis.

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Appendix A

Criteria for Diagnosis and Coding

I. Sound tooth : A tooth is recorded as sound if it shows no evidence of treated or untreated clinical caries.

II. Decayed tooth : Caries is recorded as present when a lesion in a pit or fissure or on a free smooth tooth surface has a detectably softened floor, undermined enamel, or a softened wall, or the tooth has a temporary filling. On approximal surfaces the explorer point must enter a lesion with certainty. Where any doubt exists caries should not be recorded as present. The stages of caries that precede cavitation as well as other conditions similar to the early stages of caries are deliberately excluded because they cannot be diagnosed positively and reliably. Defects not to be counted as caries in the absence of other positive criteria are:

- White or chalky spots;
- Discoloured or rough spots;
- Stained pits or fissures in the enamel that catch the explorer but do not have a detectably softened floor, undermined enamel, or softening of the walls.

III. Filled tooth with no decay : Teeth are considered filled without decay whenever one ore more permanent restorations are present and there is no secondary (recurrent) caries or other area of the tooth with primary caries. A tooth with a crown placed because of previous decay in recorded in this category. A tooth that is crowned for reasons other than decay, e.g., trauma or as a bridge abutment, is recorded as EXCLUDED.

IV. Filled tooth with primary decay : A tooth is scored as filled with primary decay when it contains one or more permanent restorations and also one or more areas that are decayed but have no obvious physical association with the restoration(s).

V. Filled tooth with secondary decay : A tooth is recorded as filled with secondary decay when it contains one ore more permanent restorations and there is secondary decay (in physical contact with the restoration(s)). If a tooth is filled and contains both primary and secondary decay it should be recorded in this category.

VI. Primary tooth missing owing to caries (under 9 years old only) : This score is used only for primary teeth missing at an age when normal exfoliation would not be a sufficient explanation for absence.

VII. Permanent tooth missing owing to caries (under 30 years) : This score is used only for permanent teeth and for persons under 30 years of age. In as much as very few teeth are extracted because of periodontal diseases in a person under 30 years of age, all extracted teeth (except those included under category VI) in persons up to the age of 30 years should be recorded as having been extracted because of caries. One problem that may be encountered, particularly in some age groups, is to distinguish between unerupted teeth and teeth extracted because of caries. Basic knowledge of tooth eruption patterns, the status of the corresponding contralateral tooth, the appearance of the alveolar ridge in the area of the tooth space in question, and the caries status of other teeth in the mouth may provide helpful clues in making a differential diagnosis between unerupted and extracted teeth.

VIII. Permanent tooth missing for reasons other than caries (under 30 years) : This score is used for permanent teeth judged to be absent congenitally or extracted for orthodontic reasons.

IX. Permanent tooth missing for any reason (30 years of age and older) : This score also is used only for permanent teeth. Since it becomes extremely difficult in older persons to ascertain whether permanent teeth have been extracted because of dental caries or on account of periodontal diseases, all extracted teeth in persons aged 30 years or more are recorded in this category.

X. Unerupted tooth : This classification is restricted to permanent teeth and used only for a tooth space with an unerupted permanent tooth, but no primary tooth, present. Teeth scored as unerupted are, of course, excluded from all calculations concerning dental caries. For differential diagnosis between extracted and unerupted teeth see section (VII), permanent tooth missing owing to caries.

XI. Excluded tooth : A permanent or primary tooth should be excluded from calculations concerning dental caries if it has been restored for reasons other than caries, such as trauma, cosmetic purposes, or as an abutment for a bridge.

Appendix B

Descriptive Criteria and Scoring System for the Tooth Surface Index of Fluorosis (TSIF)

Numerical score	Descriptive criteria
0	Enamel shows no evidence of fluorosis
1	Enamel shows definite evidence of fluorosis, namley areas with parchment-white color that total less than one-third of the visible enamel surface. This category includes fluorosis confined only to incisincisal edges of anterior teeth and cusp tips of posterior teeth (snowcapping).
2	Parchment-white fluorosis totals at least one-thirds of the visible surfaces, but less than two-thirds.
3	Parchment-white fluorosis totals at least two-thirds of the visible surface
4	Enamel shows staining in conjunction with any of the preceding levels of fluorosis. staining is defined as an area of definite discoloration that may range from light to very dark brown.
5	Discrete pitting of the enamel exists, unaccompanied by evidence of staining of intact enamel. A pit is defined as a definite physical defect in the enamel surface with a rough floor that is surrounded by a wall of intact enamel. The pitted area is usually stained or differs in color from the surrounding enamel.
6	Both discrete pitting and staining of the intact enamel exist.
7	Confluent pitting of the enamel surface exists. Large areas of enamel may be missing and the anatomy of the tooth may be altered. Dark-brown stain is usually present.

Appendix C

Supplement Prescribed Dosage

AGE	H O-fluoride content	Recommended dosage
0-18 months	0-0.5 mg/L	2 drops/day
18 months-3 years	0-0.5 mg/L	4 drops/day
over 3 years	0-0.5 mg/L	8 drops/day
0-18 month	0.5-0.99 mg/L	1 drop /day
18 months-3 years	0.51-0.75 mg/L	3 drops/day
over 3 years	0.51-0.75 mg/L	6 drops/day
18 months-3 years	0.76-0.99 mg/L	2 drops/day
over 3 years	0.76-0.99 mg/L	4 drops/day

Appendix D

Questionnaire 1

1. Child's Name 2. Boy Girl
3. Child's Date of Birth Day Month Year
4. Length of time lived in present home (please check one that applies)
   - less than one year
   - one to two years
   - two to five years
   - longer than five years
5. If your child has lived in his/her present home for less than five years, where did he/she live just before?
6. Is your current drinking water (please check one that applies)
   - from the town/city ?
   - from your own well ?
   - from a spring ?
8. Did you breastfeed this child? No yes
9. if yes to approximately what age did you breastfeed your child?
   - less than one month
   - one month to three months
   - four to six months
   - longer than six months
10. At what age did your child start using toothpaste?
    - About one year
    - Between 1 and 2 years
    - Between 2 and 3 years
    - After 3 years of age

The last question pertain to the use of home fluoride supplements provided by the health unit. If your child is currently using fluoride drops, or has taken fluoride drops in the past, (please check the response which applies).

11. Do you now, or did you normally give fluoride drops to your child

every day

4 to 6 times every week

three times a week or less

irregularly (when remembered)

never

Appendix E

Questionnaire 2

1. When did the child start taking the drops by himself?
2. How were the fluoride drops given ?
   a) with milk
   b) with juice
   c) directly into the mouth
   d)others
3. How often were they given ?
   a) every day
   b) 4 to 6 times every week
   c) three times a week or less
   d) once a week
   e) once every two weeks
   f) two or three times a month
4. Was any attempt made to catch up after stopping for a while ?
   Yes No
5. At what age did your child stop taking the fluoride drops?
   if yes, Why ?
6. Did you ever exceed the recommended dosage? Yes No
7. If you have several children taking the drops, did you give each child the exact amount that should be given? Yes No
   OR, was it equally divided among the children? Yes No
8. Have your child had topical fluoride? Yes No
   If yes, once a year twice a year Few times

Appendix F

Command File

```
title 'control and cases'
file handle manal/name='lab1'
data list file=manal/sex 1 age 4-5 stp 8-9(1) bf 12 rs 15 dmft 18
dmfs 21-22 DMFT1 25 DMFS1 28-29 flur 32 comp 35 group 38
recode stp (1.5=2) (2.5=3) (3=4)/

variables labels
 sex 'female or male'
 age '07  or 12'
 stp 'starting toothpaste usage'
 bf 'period of breast feeding'
 rs 'residency in Edmonton'
 dmft 'primary decayed missing filled teeth '
 dmfs 'primary decayed missing filled surfaces'
 DMFT1 'permanent decayed missing filled teeth'
 DMFS1 'permanent decayed missing filled surfaces'
 flur 'fluorosis'
 comp 'compliance'
 group'study or control group'
value labels
 sex 1'male' 2'female'
 age 07 '7-9 years' 12 '11-14 years'
 stp 1'1 year old'2'1-2 years old'3'2-3 years old'4'after 3 years'
 bf 0'no or <1 month ' 1'1-3 month'2'4-6 month'3'>6 month'
```

rs 1 'more than 5 years'0 'less than 5 years'

flur 0 'absent' 1 'present '

comp 1 'poor compliance 2 'good compliance '

group 1 'control ' 2 'study'